interstate carrier access services as a group—is illusory. When output price data are adjusted to keep earnings constant across the historical period, accounting costs must be assigned to individual services.[42] That assignment is no different—in principle—from the measurement of interstate access TFP growth from Part 36 and Part 69 cost and revenue data, which is acknowledged to be inappropriate. Second, while duality implies that TFP growth measured by quantities and prices will be the same, it does not suggest that failure of any of the assumptions of the method will have the same effect on the two TFP growth measures.

For example, suppose economic earnings vary from year to year during the historical period. TFP growth measured by quantities could differ markedly from TFP growth measured by prices. If prices are adjusted in each period to keep measured economic earnings constant, errors in the adjustment would affect TFP as measured by prices more than TFP as measured by quantities. Using the historical price method, TFP growth is calculated from *changes* in prices (i.e., the difference between the rates of growth of input and output prices). Using the quantity method, prices enter the TFP growth calculation only

(i) as part of the revenue and expenditure weights used to calculate aggregate quantity indices of outputs and inputs; and

(ii) as *levels* rather than annual changes.

Thus errors in measuring input or output prices (or adjusting output prices to keep accounting earnings constant) have a larger effect on TFP growth as measured by price rather than quantity. Possibly for these reasons, it is instructive to note that, without exception, empirical studies of productivity growth use quantity indices rather than price indices.[43]

Third, the practical decision whether to base historical measurements on quantities or prices must take into account the use to which the measurement will be put. In the present

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[42] Thus when NERA and Frentrup-Uretsky calculated X using the historical price method in CC Docket No. 87-313, they adjusted prices to hold earnings constant, and that adjustment required the calculation of the total cost of interstate switched access services. The calculation therefore erroneously assigns a portion of the fixed costs of the LECs to interstate switched access services and presented arbitrary and incorrect estimates of TFP.

[43] See, for example, D. Jorgenson, F. Gollop and B. Fraumeni, *Productivity and U.S. Economic Growth*, Cambridge: Harvard University Press, 1987, at 4 and 152-159.

exercise, the results will be used essentially to forecast future values of productivity growth to determine a reasonable target productivity growth for the price-cap regulated LECs. Since productivity growth—relative to U.S. average productivity growth—is the ultimate source of real price reductions in any market, it is preferable to study productivity growth directly, rather than indirectly through the price changes that follow from productivity growth. In particular, possible differences between the historical period and the future will be easier to quantify directly in terms of productivity growth than indirectly in terms of output price growth.[44]

Finally, the duality of price and output-based measures of productivity growth can be used as to check results. As discussed above, we cannot use duality to reconcile the historical price calculations for interstate switched access services with the quantity-based productivity measures calculated by Christensen: the latter applies to all the firm's services and would be comparable only to a price-based productivity study performed on all of the firm's services.

It is straightforward to compare a price-based measure of the achieved X for the telecommunications industry with the historical X calculated by Christensen. Indeed, the Commission Staff has already performed such a comparison: the Spavins-Lande studies filed in CC Docket No. 87-313 are long run measures of the X achieved by the telecommunications industry.[45] As updated through 1993 in the NERA Reply Comments, the long run (1929-1993) productivity offset calculated from telecommunications industry price data averaged about 2.1 percent, unchanged from the Spavins-Lande finding for the 1929-1987 period. Applying the method to the post-divestiture period, we find that the Spavins-Lande historical price-based value of X for the period examined in the Christensen direct studies (1984-1993) is 2.4 percent which corresponds reasonably closely with the value of X proposed by Dr. Christensen which uses the long run input price differential of 0. This

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[44] This difference is particularly relevant when prices were regulated differently between the historical period and the future. Much of the work in the original studies in CC Docket 87-313 using the historical price method was done to correct measured prices for changes over time in regulatory rules and procedures.

[45] *Supplemental Notice of Proposed Rulemaking*, CC Docket 87-313, March 12, 1990, Appendix D and *Second Report and Order*, CC Docket 87-313, October 4, 1990, Appendix D.

correspondence provides some confirmation that—at the level of aggregation of the entire firm—the historical price method and the direct TFP method yield similar results, as they should under the principles of duality.[46]

In summary, although economic theory suggests that prices and quantities can be used symmetrically to calculate productivity growth, there are serious practical concerns with historical price-based methods in these circumstances. Price-based methods can replicate accurately the outcome of historical regulation on prices and can determine an *X* that will assure customers that real price growth will be slower under price regulation than it had been under the historical regulatory regime. However, to give economic support to the historical price method requires (i) that prices be adjusted to undo the multitude of regulatory changes over time and (ii) that the analysis be undertaken at the level of the total firm rather than interstate services or individual services.[47] When that analysis is undertaken, we see that the historical price method yields approximately the same historical value of the X-Factor as obtained from the direct measurement of TFP growth based on input and output quantities.

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[46] Note that if the short run point estimate of the input price differential were added to Dr. Christensen's TFP differential, the correspondence between the direct and dual estimates of industry productivity would disappear. This fact implies that only the long-run adjustment for differences in input price growth rates—essentially zero—is consistent with both the empirical evidence and the implications of duality.

[47] Note that measures of the historical productivity offset based on carrier access prices proposed in this Docket do not give such support because they are undertaken for only a subset of the LEC's services.

VI. THE CONSUMER PRODUCTIVITY DIVIDEND

Paragraphs 94-95 of the *FFN* note that a consumer productivity dividend (CPD) was originally added to the historical X factor (calculated prior to price regulation) to ensure that customers benefited from the anticipated increase in the rate of growth of TFP stemming from the adoption of price cap regulation. The *FFN* then asks if a CPD should again be added to an historical X factor measured over a period in which price cap regulation were in force. There are at least two reasons why—irrespective of the announced level of the productivity offset—a continued or additional CPD is not warranted. First, adding a CPD to an historical X factor measured over a period that includes price cap regulation would effectively double-count expected productivity gains from regulatory reform. Second, interstate price caps are currently approximately 2.5 percent lower than would otherwise have been because of the 0.5 percent CPD put in place at the beginning of price cap regulation for LECs. It is unclear why a shift to an improved form of regulation in the past would continue to yield additional efficiencies in the future. One might think that a one-time reduction in prices should be required to match a one-time reduction in costs from improved regulation. However, because it is built in as part of the productivity offset, the interstate CPD automatically increases over time. Indeed, since 1991, some five years of a CPD are embedded in the LECs' current rates.

VII. CONCLUSION

Three important areas of Commission concern are addressed in this study. First, evidence regarding the magnitude and uncertainty of the measured input price differential in a price cap plan suggests that point estimates calculated over a relatively short period of time are too unreliable to support their use in a mechanical formula. If a productivity target were increased to account for the post-divestiture difference in LEC and U.S. input price growth, the LECs would be doubly penalized when interest rates begin to rise and LEC input prices begin to rise more rapidly than those of the U.S. as a whole.

Second, use of historical TFP measures to determine the productivity offset in the price adjustment formula is reasonable. Productivity growth must be calculated at the level of

the entire firm. Efforts to calculate service-specific productivity growth are misguided because the production function for telecommunications services is not separable for interstate and intrastate services, for regulated and nonregulated services, or for finer disaggregates of services. It is not possible to estimate service-specific TFP growth. Similarly, adjustments to total firm measures of productivity growth to account for differential output growth or contribution by service are also improper because there is no underlying difference in productivity growth rates across services for these adjustments to approximate.

Third, while calculating productivity growth from price or earnings data is possible in theory, it is more academic than practical. The Historical Revenue method requires that accounting measures of earnings and depreciation correspond to economic concepts and that price cap regulation have been applied correctly and consistently over the historical period. Similarly, the Historical Price Method requires that the price data be adjusted to keep measured economic earnings constant, and errors in those adjustments are likely to have a larger effect on measured TFP growth than when direct, quantity-based measures of productivity growth are calculated. But the main drawback to both approaches is that—despite appearances—they cannot produce meaningful productivity growth measures for LEC interstate services. Productivity growth for LEC interstate services calculated by these methods entails tacit assignments of fixed common costs to particular services, so that the resulting measure of productivity growth is as arbitrary as the undefined concept—the productivity growth of a subset of services connected through fixed common costs—it attempts to quantify. Such measures have no theoretical support in economics and can play no useful role in the measurement of productivity growth to set the parameters of a price cap plan.

Economic Evaluation of Selected Issues From the Fourth Further Notice of Proposed Rulemaking in the LEC Price Cap Performance Review

Attachment A

REGRESSION: TELEPHONE INPUT PRICE GROWTH - CHRISTENSEN 1 DATA

Year	LEC Input Price Change	U.S. Input Price Change	Divestiture Binary Dummy	Moody's Pub Util Bonds	1990-2 Dummy
A	B	C	E	D	E
1949	3.2%	-1.0%	0	2.66%	0
1950	5.1%	6.3%	0	2.62%	0
1951	8.8%	7.9%	0	2.86%	0
1952	8.6%	1.2%	0	2.96%	0
1953	2.4%	3.7%	0	3.20%	0
1954	1.9%	0.6%	0	2.90%	0
1955	5.4%	6.6%	0	3.06%	0
1956	1.7%	0.7%	0	3.36%	0
1957	-1.1%	3.7%	0	3.89%	0
1958	3.3%	0.5%	0	3.79%	0
1959	5.4%	7.0%	0	4.38%	0
1960	4.2%	-0.6%	0	4.41%	0
1961	3.9%	3.6%	0	4.35%	0
1962	2.2%	4.4%	0	4.33%	0
1963	1.0%	3.8%	0	4.26%	0
1964	6.0%	4.5%	0	4.40%	0
1965	0.5%	5.7%	0	4.49%	0
1966	1.1%	4.6%	0	5.13%	0
1967	1.9%	2.0%	0	5.51%	0
1968	4.2%	4.4%	0	6.18%	0
1969	2.1%	3.7%	0	7.03%	0
1970	3.8%	3.3%	0	8.04%	0
1971	4.2%	6.8%	0	7.39%	0
1972	8.0%	7.2%	0	7.21%	0
1973	0.6%	6.3%	0	7.44%	0
1974	5.9%	4.2%	0	8.57%	0
1975	14.2%	9.4%	0	8.83%	0
1976	10.7%	9.1%	0	8.43%	0
1977	6.1%	8.6%	0	8.02%	0
1978	7.6%	7.8%	0	8.73%	0
1979	7.2%	8.2%	0	9.63%	0
1980	14.6%	6.6%	0	11.94%	0
1981	11.6%	9.9%	0	14.17%	0
1982	12.1%	3.7%	0	13.79%	0
1983	12.8%	5.6%	0	12.04%	0
1984	1.8%	7.4%	1	12.71%	0
1985	0.1%	4.0%	1	11.37%	0
1986	1.3%	3.8%	1	9.02%	0
1987	1.7%	3.1%	1	9.38%	0
1988	-3.2%	4.4%	1	9.71%	0
1989	-3.7%	4.1%	1	9.26%	0
1990	11.9%	4.2%	1	9.32%	1
1991	1.3%	2.9%	1	8.77%	1
1992	4.4%	5.1%	1	8.14%	1

Permanent Shift Hypothesis (Bush-Uretsky)

Constant	-0.0027
Std Err of Y Est	0.0347
R Squared	0.4322
No. of Observations	44
Degrees of Freedom	40

	US IPr	Divestiture	Moody
X Coefficient(s)	0.3402	-0.0579	0.6489
Std Err of Coef.	0.2338	0.0152	0.2093
t-Statisic	1.4553	-3.8142	3.1007
F-statistic	10.1512		
(3,40)			

Temporary Shift Hypothesis

Constant	-0.0061
Std Err of Y Est	0.0309
R Squared	0.5600
No. of Observations	44
Degrees of Freedom	39

	US IPr	Divestiture	Moody	1990-1992
X Coefficient(s)	0.3209	-0.0851	0.7174	0.0740
Std Err of Coef.	0.2085	0.0158	0.1877	0.0220
t-Statisic	1.5392	-5.3981	3.8225	3.3658
F-statistic	12.4114			
(4,39)				

Source: CC: Docket 94-1, First Report and Order, Released April 7, 1995. Appendix F, Christensen Affidavit Data

REGRESSION: TELEPHONE INPUT PRICE GROWTH - CHRISTENSEN 2 DATA

Year	LEC Input Price Change	U.S. Input Price Change	Divestiture Binary Dummy	Yield on Moody's Pub Util Bonds	1990-2 Dummy
A	B	C	D	E	F
1960	2.4%	1.7%	0	4.41%	0
1961	4.0%	2.9%	0	4.35%	0
1962	3.1%	4.5%	0	4.33%	0
1963	4.9%	3.9%	0	4.26%	0
1964	2.4%	5.4%	0	4.40%	0
1965	2.4%	4.4%	0	4.49%	0
1966	1.5%	5.5%	0	5.13%	0
1967	5.0%	2.8%	0	5.51%	0
1968	6.1%	6.4%	0	6.18%	0
1969	2.7%	4.0%	0	7.03%	0
1970	4.0%	3.2%	0	8.04%	0
1971	6.5%	6.6%	0	7.39%	0
1972	7.6%	6.0%	0	7.21%	0
1973	6.6%	8.6%	0	7.44%	0
1974	4.8%	4.2%	0	8.57%	0
1975	9.3%	8.5%	0	8.83%	0
1976	9.2%	9.2%	0	8.43%	0
1977	4.8%	7.3%	0	8.02%	0
1978	7.3%	7.0%	0	8.73%	0
1979	2.9%	7.7%	0	9.63%	0
1980	6.9%	7.0%	0	11.94%	0
1981	11.0%	9.5%	0	14.17%	0
1982	9.3%	3.1%	0	13.79%	0
1983	13.7%	6.2%	0	12.04%	0
1984	1.8%	6.5%	1	12.71%	0
1985	0.1%	4.0%	1	11.37%	0
1986	1.3%	3.8%	1	9.02%	0
1987	1.7%	3.2%	1	9.38%	0
1988	-3.2%	4.6%	1	9.71%	0
1989	-3.7%	4.2%	1	9.26%	0
1990	11.9%	4.3%	1	9.32%	1
1991	1.3%	2.9%	1	8.77%	1
1992	4.4%	5.1%	1	8.14%	1

Permanent Shift Hypothesis (Bush-Uretsky)

Constant			-0.0046
Std Err of Y Est			0.0308
R Squared			0.4440
No. of Observations			33
Degrees of Freedom			29
	US IPr	Divestiture	Moody
X Coefficient(s)	0.3140	-0.0480	0.5794
Std Err of Coef.	0.3179	0.0144	0.2350
t-Statistic	0.9878	-3.3365	2.4653
F-statistic	7.7208		
(3,29)			

Temporary Shift Hypothesis

Constant				-0.0111
Std Err of Y Est				0.0247
R Squared				0.6553
No. of Observations				33
Degrees of Freedom				28
	US IPr	Divestiture	Moody	1990-1992
X Coefficient(s)	0.2774	-0.0752	0.6916	0.0731
Std Err of Coef.	0.2549	0.0133	0.1903	0.0177
t-Statistic	1.0881	-5.6677	3.6345	4.1423
F-statistic	13.3067			
(4,28)				

Source: CC: Docket 94-1, First Report and Order, Released April 7, 1995. Appendix F, NERA Data

REGRESSION: INPUT PRICE DIFFERENTIAL - CHRISTENSEN 1 DATA

Year	LEC-US Input Price Growth	Divest Binary Dummy	Moody's Pub Util Bonds	1990-2 Dummy
A	B	C	D	E
1949	4.2%	0	2.66%	0
1950	-1.2%	0	2.62%	0
1951	0.9%	0	2.86%	0
1952	7.4%	0	2.96%	0
1953	-1.3%	0	3.20%	0
1954	1.3%	0	2.90%	0
1955	-1.2%	0	3.06%	0
1956	1.0%	0	3.36%	0
1957	-4.8%	0	3.89%	0
1958	2.8%	0	3.79%	0
1959	-1.6%	0	4.38%	0
1960	4.8%	0	4.41%	0
1961	0.3%	0	4.35%	0
1962	-2.2%	0	4.33%	0
1963	-2.8%	0	4.26%	0
1964	1.5%	0	4.40%	0
1965	-5.2%	0	4.49%	0
1966	-3.5%	0	5.13%	0
1967	-0.1%	0	5.51%	0
1968	-0.2%	0	6.18%	0
1969	-1.6%	0	7.03%	0
1970	0.5%	0	8.04%	0
1971	-2.6%	0	7.39%	0
1972	0.8%	0	7.21%	0
1973	-5.7%	0	7.44%	0
1974	1.7%	0	8.57%	0
1975	4.8%	0	8.83%	0
1976	1.6%	0	8.43%	0
1977	-2.5%	0	8.02%	0
1978	-0.2%	0	8.73%	0
1979	-1.0%	0	9.63%	0
1980	8.0%	0	11.94%	0
1981	1.7%	0	14.17%	0
1982	8.4%	0	13.79%	0
1983	7.2%	0	12.04%	0
1984	-5.6%	1	12.71%	0
1985	-3.9%	1	11.37%	0
1986	-2.5%	1	9.02%	0
1987	-1.4%	1	9.38%	0
1988	-7.6%	1	9.71%	0
1989	-7.8%	1	9.26%	0
1990	7.7%	1	9.32%	1
1991	-1.6%	1	8.77%	1
1992	-0.7%	1	8.14%	1

Permanent Shift Hypothesis (Bush-Uretsky)

Constant		-0.0157
Std Err of Y Est		0.0375
R Squared		0.1702
No. of Observations		44
Degrees of Freedom		41
	Divestiture	Moody
X Coefficient(s)	-0.0440	0.3464
Std Err of Coef.	0.0155	0.1944
t-Statistic	-2.8330	1.7818
F-statistic	4.2036	
(2,41)		

Temporary Shift Hypothesis

Constant			-0.0194
Std Err of Y Est			0.0344
R Squared			0.3179
No. of Observations			44
Degrees of Freedom			40
	Divestiture	Moody	1990-1992
X Coefficient(s)	-0.0701	0.4045	0.0721
Std Err of Coef.	0.0168	0.1796	0.0245
t-Statistic	-4.1737	2.2527	2.9429
F-statistic	6.2128		
(3,40)			

Source: CC: Docket 94-1, First Report and Order, Released April 7, 1995. Appendix F, Christensen Affidavit Data

REGRESSION: INPUT PRICE DIFFERENTIAL - CHRISTENSEN 2 DATA

Year	LEC-US Input Price Growth	Divestiture Binary Dummy	Yield on Moody's Pub Util Bonds	1990-2 Dummy
A	B	B	D	E
1960	0.7%	0	4.41%	0
1961	1.1%	0	4.35%	0
1962	-1.4%	0	4.33%	0
1963	1.0%	0	4.26%	0
1964	-3.0%	0	4.40%	0
1965	-2.0%	0	4.49%	0
1966	-4.0%	0	5.13%	0
1967	2.2%	0	5.51%	0
1968	-0.3%	0	6.18%	0
1969	-1.3%	0	7.03%	0
1970	0.8%	0	8.04%	0
1971	-0.1%	0	7.39%	0
1972	1.6%	0	7.21%	0
1973	-2.0%	0	7.44%	0
1974	0.6%	0	8.57%	0
1975	0.8%	0	8.83%	0
1976	0.0%	0	8.43%	0
1977	-2.5%	0	8.02%	0
1978	0.3%	0	8.73%	0
1979	-4.8%	0	9.63%	0
1980	-0.1%	0	11.94%	0
1981	1.5%	0	14.17%	0
1982	6.2%	0	13.79%	0
1983	7.5%	0	12.04%	0
1984	-4.7%	1	12.71%	0
1985	-3.9%	1	11.37%	0
1986	-2.5%	1	9.02%	0
1987	-1.5%	1	9.38%	0
1988	-7.8%	1	9.71%	0
1989	-7.9%	1	9.26%	0
1990	7.6%	1	9.32%	1
1991	-1.6%	1	8.77%	1
1992	-0.7%	1	8.14%	1

Permanent Shift Hypothesis (Bush-Uretsky)

Constant		-0.0251
Std Err of Y Est		0.0327
R Squared		0.1848
No. of Observations		33
Degrees of Freedom		30
	Divestiture	Moody
X Coefficient(s)	-0.0338	0.3419
Std Err of Coef.	0.0135	0.2200
t-Statistic	-2.4935	1.5543
F-statistic	3.4001	
(2,30)		

Temporary Shift Hypothesis

Constant		-0.0325	
Std Err of Y Est		0.0275	
R Squared		0.4395	
No. of Observations		33	
Degrees of Freedom		29	
	Divestiture	Moody	1990-1992
X Coefficient(s)	-0.0596	0.4390	0.0714
Std Err of Coef.	0.0135	0.1874	0.0197
t-Statistic	-4.4281	2.3422	3.6299
F-statistic	7.5787		
(3,29)			

Source: CC: Docket 94-1, First Report and Order, Released April 7, 1995. Appendix F, NERA Data

Appendix D

NYNEX Response To X-Factor NPRM ¶¶ 42 And 44 Regarding Data Corrections On Replacement Values And Plant Additions

In paragraph 42 of the X-Factor NPRM, the Commission seeks comment on the data used in the Christensen Study to compute replacement values. The Commission makes reference to errors that USTA identified in the original version of the Christensen Study, which were corrected by the LECs in the 1993 Christensen Update and explained through a USTA Ex Parte Statement submitted February 3, 1995.

These corrections were made by the LECs, in coordination with USTA, to 1984-1992 data submitted for the original Christensen Study. In all cases, these changes were made to ensure accuracy of the Christensen TFP Study. The analysis and work effort associated with these changes are indicative of the extent to which these parties have attempted to provide complete and accurate data in this proceeding.

One of these data corrections was to NYNEX 1984 Replacement Costs. During the 1993 update to the Christensen Study, the NYNEX 1984 Replacement Costs were questioned by Christensen and Associates based upon a comparison of Replacement Costs to Telephone Plant In Service ("TPIS") for 1984. This comparison indicated that the replacement costs and book costs that were reported yielded an unreasonable Current Cost/Book Cost ("CC/BC") ratio. Upon review, it was determined that in developing the 1984 replacement costs in the original study, TPIs were applied to incorrect book costs for NYNEX.

In paragraph 44 of the X-Factor NPRM, the Commission seeks explanation on corrections made by the LECs to plant additions data. NYNEX, as well as a number of other companies, made corrections to previously submitted plant additions data with the 1993

Christensen Update. These corrections were also explained in the USTA February 3, 1995 Ex Parte. NYNEX corrected the plant additions data because:

- The original data for New York Telephone were from a source that did not tie directly to ARMIS.

- The originally submitted New York Telephone data were "net additions" (adjusted for retirements and transfers) while New England Telephone data were "new additions" only. The revised data changed the New York Telephone methodology to reflect "new additions" only.

- The originally submitted New England Telephone data for Central Office Equipment reflected a composite of all Central Office Switching as well as Circuit and Radio Equipment resulting in a double-count of Circuit Equipment. The revised data for New England Telephone for Central Office Equipment now reflect only Switching Equipment. Circuit and Radio Equipment are listed separately.

- The originally submitted data for both companies for Transmission Equipment included only Circuit Equipment. The revised data for Transmission Equipment now reflect Circuit Equipment and Radio Equipment.

- The originally submitted data for Cable and Wire did not include plant additions for Poles and Conduit. The revised data include Poles and Conduit additions in the Cable and Wire category.

These corrections were made to provide a consistent methodology for both NYNEX Telephone Companies and to conform to the industry method that plant additions data correspond to the Form M definitions used to construct the Asset Categories.

On February 17, 1995, USTA submitted an Ex Parte sensitivity analysis which demonstrates the impact of all data corrections on the industry TFP result. The sensitivity analysis indicates that the data corrections have only a minor effect on the TFP result. Paragraph 1 of the Ex Parte states:

> the data corrections, incrementally and in total, have only minor effects on the LEC TFP growth, output growth, input growth, and

> the LEC-U.S. economy TFP growth differential. Moreover, given that the majority of these data corrections have resulted in data that are consistent with officially reported data, we would not expect to see such corrections on a going forward basis.

The Table on page 1 of that USTA Ex Parte illustrates the results of all data corrections to the 1984-1992 TFP Study and shows that the correction of NYNEX 1984 Replacement Costs impacts LEC TFP Growth by only "one tenth of one percent" or 0.1% (2.6%-2.5%). Additionally, the sensitivity analysis shows that the aggregation of all data corrections for all companies impacts LEC TFP Growth by only 0.2% (2.6%-2.4%). These changes, which have only minimal impact on the TFP result, show a concerted effort by the industry to improve the LEC TFP study by providing more accurate data based on consistent definitions and methodology.

The effort which the LECs have undertaken for the TFP analysis to correct data obtained from "local company sources," and the concerns which the Commission has raised, underscore the value of the adoption of the revised Christensen TFP methodology which relies solely on public verifiable data.